

Claims

What is claimed is:

1. A control system for a work machine having at least one hydraulic actuator, comprising:
  - an input device adapted to generate a movement signal to control the movement of the at least one hydraulic actuator;
  - a sensor operatively engaged with the at least one hydraulic actuator and adapted to sense a parameter indicative of a magnitude of a force exerted by the hydraulic actuator;
  - a first controller disposed on the work machine and adapted to control the motion of the at least one hydraulic actuator, the first controller having a first receiver adapted to receive the movement signal and a first transmitter adapted to transmit a force signal including an indication of the force exerted by the hydraulic actuator;
  - a second controller operatively connected to the input device, the second controller having a second transmitter adapted to transmit the movement signal and a second receiver adapted to receive the force signal; and
  - a force generator operatively engaged with the input device and adapted to exert a feedback force on the input device, the magnitude of the feedback force being related to the magnitude of the force exerted by the hydraulic actuator.
2. The control system of claim 1, wherein the input device includes a joystick.
3. The control system of claim 1, wherein the force generator includes at least one of an electromagnet, a spring, and a hydraulic actuator.

4. The control system of claim 1, further including a second sensor adapted to sense a parameter indicative of a magnitude of a velocity of the hydraulic actuator and wherein the first transmitter transmits a velocity signal to the second receiver.

5. The control system of claim 1, further including a control valve associated with the hydraulic actuator and wherein the first controller controls the position of the control valve to thereby control the movement of the hydraulic actuator.

6. The control system of claim 1, wherein the sensor is adapted to sense a pressure indicative of the pressure of a fluid in the hydraulic actuator.

7. The control system of claim 1, wherein the magnitude of the feedback force is proportional to the magnitude of the force.

8. A method of remotely controlling a work machine, comprising:  
transmitting a movement signal from a remote input device to a controller disposed on a work machine;  
moving at least one hydraulic actuator disposed on the work machine in response to the movement signal;  
sensing a parameter indicative of a magnitude of a force exerted by the at least one hydraulic actuator;  
transmitting a force signal having an indication of the magnitude of the force exerted by the at least one hydraulic actuator; and  
exerting a feedback force on the input device, the magnitude of the feedback force being related to the magnitude of the force exerted by the hydraulic actuator.

9. The method of claim 8, wherein the step of sensing a parameter includes sensing a pressure representative of a fluid pressure in the at least one hydraulic actuator.

10. The method of claim 8, further including manipulating a joystick to generate the movement signal.

11. The method of claim 8, wherein the movement of the at least one hydraulic actuator results in the movement of a work implement disposed on the work machine.

12. The method of claim 8, further including:  
sensing a parameter indicative of a velocity of the at least one hydraulic actuator; and  
transmitting a velocity signal having an indication of the magnitude of the velocity of the at least one hydraulic actuator.

13. A remote control system for a work machine system, comprising:  
a work machine having a ground engaging device, a work implement, and at least one hydraulic actuator;  
an input device adapted to generate a movement signal to control the movement of the at least one hydraulic actuator;  
a sensor operatively engaged with the at least one hydraulic actuator and adapted to sense a parameter indicative of a magnitude of a force exerted by the hydraulic actuator;  
a first controller disposed on the work machine and adapted to control the motion of the at least one hydraulic actuator, the first controller having a first receiver adapted to receive the movement signal and a first transmitter adapted to transmit a force signal including an indication of the force exerted by the hydraulic actuator;

a second controller operatively connected to the input device, the second controller having a second transmitter adapted to transmit the movement signal and a second receiver adapted to receive the force signal; and

a force generator operatively engaged with the input device and adapted to exert a feedback force on the input device, the magnitude of the feedback force being related to the magnitude of the force exerted by the hydraulic actuator.

14. The system of claim 13, wherein the force generator includes at least one of an electromagnet, a spring, and a hydraulic actuator.

15. The system of claim 13, further including a second sensor adapted to sense a parameter indicative of a magnitude of a velocity of the hydraulic actuator and wherein the first transmitter transmits a velocity signal to the second receiver.

16. The system of claim 13, wherein the work machine includes a control valve adapted to control the movement of the at least one hydraulic actuator and the first controller controls the position of the control valve to thereby control the movement of the hydraulic actuator.

17. The system of claim 13, wherein the sensor is adapted to sense a pressure indicative of the pressure of a fluid in the hydraulic actuator.

18. The system of claim 13, wherein the magnitude of the feedback force is proportional to the magnitude of the force.

19. The system of claim 13, wherein the work machine includes a work tool mounted on a work implement and a plurality of hydraulic actuators adapted to move the work implement and the work tool.

20. The system of claim 19, further including a plurality of sensors associated with the plurality of hydraulic actuators, each of the plurality of sensors adapted to sense a parameter indicative of a magnitude of a force exerted by the respective hydraulic actuator.

21. The system of claim 20, wherein the first controller is adapted to determine a magnitude and a direction of a resulting force exerted by the work implement based on the parameters sensed by each of the plurality of sensors.

22. The system of claim 19, wherein the input device includes a first input mechanism adapted to control the motion of the work implement and a second input mechanism adapted to control the motion of the ground engaging device.

23. A control system for a work machine having at least one hydraulic actuator, comprising:

an input means for generating a movement signal to control the movement of the at least one hydraulic actuator;

a sensing means for sensing a parameter indicative of a magnitude of a force exerted by the hydraulic actuator;

a first controlling means for controlling the motion of the at least one hydraulic actuator, the first controlling means having a first receiving means for receiving the movement signal and a first transmitting means for transmitting a force signal including an indication of the force exerted by the hydraulic actuator;

a second controlling means operatively connected to the input device, the second controlling means having a second transmitting means for transmitting the movement signal and a second receiving means for receiving the force signal; and

a means for exerting a feedback force on the input device, the magnitude of the feedback force being related to the magnitude of the force exerted by the hydraulic actuator.